PROCEEDINGS
OF THE
CALIFORNIA ACADEMY OF SCIENCES
FOURTH SERIES

Vol. XXXIII, No. 14, pp. 453–480; 1 table May 12, 1966

NEW NON-MARINE MOLLUSCA FROM THE ESMERALDA FORMATION, NEVADA

By

James R. Firby

Museum and Department of Paleontology, University of California, Berkeley

ABSTRACT: Two new species of Pelecypoda, *Sphaerium stewartensis* and *Pisidium leslieae*, and 5 new species of Gastropoda, *Vorticifex stewartensis*, *Planorbis webbi*, *Bulimnea webbi*, *Goniobasis reticulata*, and *Goniobasis leslieae*, are described from the non-marine late Tertiary Esmeralda Formation, Nye and Mineral counties, Nevada. The 7 new species are part of a non-marine molluscan fauna of 34 taxa, here referred to as the Cedar Mountain molluscan fauna. On the basis of associated fossil mammals this fauna ranges in age from Barstovian through Clarendonian (late Miocene though early Pliocene). The Cedar Mountain molluscan fauna is closely related to that of the Truckee Formation of western Nevada. The character and field relationships of the lacustrine sediments where the molluscs occur indicates lake margin or shallow water environment.

INTRODUCTION

A large non-marine fauna, including 7 new species, was collected from lacustrine sediments of the Esmeralda Formation in the vicinity of the Cedar Mountains during 1961. The area is located in west central Nevada, approximately 22 miles east of the town of Mina and 35 miles southeast of Hawthorne (see index map).

Collections were made at 42 localities in Stewart and Ione valleys. Surface prospecting techniques were employed at all localities and were augmented by dry screening at localities B-2051 and B-2052. Laboratory preparation depended on the use of small hand tools, as weak solutions of acetic acid and immersion in water were unsatisfactory for the separation of fossils from the matrix.

Specimens and locality numbers refer to collections of the Museum of Paleontology, University of California at Berkeley (*UCMP*) and the California Academy of Sciences at San Francisco (*CAS*).

I am indebted to J. Wyatt Durham, Department of Paleontology, University of California, Berkeley, for his critical reading of this manuscript. Thanks are also due J. E. Mawby and S. D. Webb, of the University of California, Berkeley, for their determinations of the fossil mammals. Financial support was graciously given by the Museum and Department of Paleontology, University of California, Berkeley.

Occurrence

The Esmeralda Formation in the area of the Cedar Mountains is represented by a series of tuffaceous sandstones, siltstone, limestones, thin beds of volcanic ash, and shale. These lacustrine beds have a thickness of over 1,400 feet in Stewart Valley and more than 1,600 feet in Ione Valley. In both valleys the sediments overlie an irregular surface of igneous rocks, and crop out on both the east and west flanks of the Cedar Mountains, from Gabbs Valley south to Big Smokey Valley, the terminus of the Cedar Mountains. The molluscs are generally abundant in the sandstones and limestones throughout the lacustrine sediments, becoming rare in the siltstones and shale and absent in the volcanic ash.

The Esmeralda Formation in this region ranges in age from late Miocene through early Pliocene. Major evidence for dating the Esmeralda Formation of this area is provided by the occurrence of fossil mammals in the same beds with the molluscs. Two North American mammalian ages, the Barstovian and the Clarendonian (as defined by Wood, *et al.*, 1941), are represented by the characteristic fossil mammals, which are listed systematically below. A geologic map of that portion of the Esmeralda Formation in Mineral County has been compiled by Ross (1961, pl. 2).

Precise locality data for all localities where molluscs were collected are given in the appendix.

List of Barstovian (late Miocene) Mammals from the Stewart Springs and Bell Springs Faunas.

Insectivora
  Erinaceidae
    Meterix latidens
  Soricidae
    Limnoecus species
  Talpidae
?Insectivora, genus undetermined
    Arctoryctes species
?Chiroptera
Rodentia
Rodentia
  Sciuridae
    Sciuridae, genus and species undetermined
    Tamias ateles
Carnivora
  Canidae
    Tomarctus species
    Aelurodon species
    Vulpes species
  Procyonidae
    Bassariscus parvus
  Mustelidae
    Mustelidae, genus and species undetermined
Proboscidea
  Gomphotheriidae
    Gomphotherium species
Perissodactyla
  Equidae
    Hypohippus species, compare *H. osborni*

- Aplodontidae
  - *Liodontia* species
- Mylagaulidae
  - *Mylagaulus* species
- Castoridae
  - *Monosaulax pansus*
  - *Anchitheriomys* species
- Heteromyidae
  - *Perognathoides* species
- Geomyidae
- Cricetinae

Lagomorpha
- Leporidae
  - *Hypolagus* species

List prepared by S. D. Webb.

LIST OF CLARENDONIAN (EARLY PLIOCENE) MAMMALS FROM THE CEDAR MOUNTAIN ESMERALDA BEDS.

Insectivora
- Soricidae
  - *Limnoecus tricuspis*

Rodentia
- Sciuridae
  - Sciuridae, genus and species undetermined
  - *Tamias ateles*
- Heteromyidae
  - *Perognathus* species, compare *P. minutus*
  - *Cupidinimus* species
  - *Perognathoides quartus*
  - *P. cuyamensis*
- Dipidomyine
  - Dipidomyine, genus and species undetermined
- Castoridae
  - *Eucastor dividerus*
- Cricetidae
  - *Peromyscus dentalis*

Lagomorpha
- Leporidae
  - *Hypolagus* species

Carnivora
- Canidae
  - ?*Tomarctus* species
  - *Vulpes* species
  - *Aelurodon taxoides*
  - *Aelurodon* species
- Mustelidae
  - Mustelidae, genus and species undetermined
- Felidae
  - *Pseudaelurus* species
  - *Sansanosmilus* species

Proboscidea
- Gomphotheriidae
  - Gomphotheriidae, genus and species undetermined

Perissocactyla
- Equidae
  - *Megahippus* species
  - *Pliohippus* species, compare *P. tantalus*
  - *Pliohippus* species
  - *Neohipparion* species
  - *Hypohippus nevadensis*
- Rhinocerotidae
  - ?*Aphelops* species

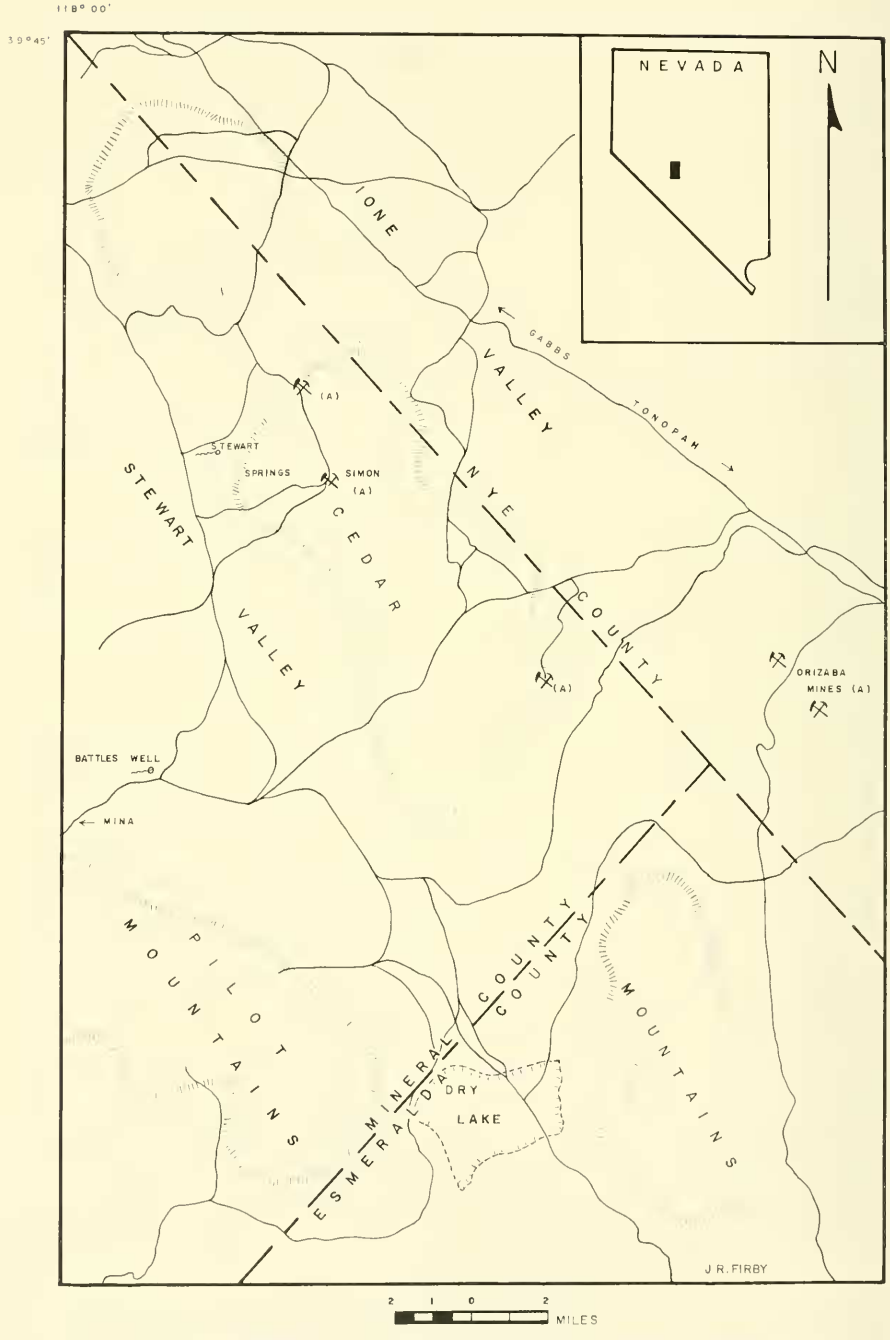
Artiodactyla
- Camelidae
  - *Procamelus coartatus*
  - *Procamelus* species
  - *Protolabis* species
- Antilocapridae
  - *Merycodus* species
  - *Merychippus brevidontus*
  - *M. californicus*
- Rhinocerotidae
  - *Teleoceras* species

Artiodactyla
- Camelidae
  - *Procamelus* species
  - *Aepycamelus* species
- Palaeomerycidae
  - Palaeomerycidae, genus and species undetermined
- Antilocapridae
  - *Merycodus furcatus*
  - *M. loxoceras*

List prepared by J. E. Mawby.

RELATED FAUNAS

The molluscan fauna of the Esmeralda Formation in the Cedar Mountain area is most closely related to that of the Truckee Formation to the north. The



INDEX MAP. Collecting area from the Esmeralda Formation, Nevada.

limited assemblage from the Silver Peak area to the south is also similar. Both faunas are probably contemporaneous, at least in part, with the Cedar Mountain molluscan fauna. Stratal continuity between the Esmeralda Formation at its type area in the Silver Peak region and lacustrine sediments at Cedar Mountain is affirmed by Buwalda (1914). The Silver Peak region is approximately 40 miles south of the Cedar Mountain area.

Portions of the Truckee Formation have been referred to a probable late Clarendonian age by Macdonald (1956), who records *Eucastor* near *E. leconti* and *Osteoborous diabloensis* from the Nightingale and Brady Pocket localities. In the upper sequence at Cedar Mountain the beaver *Eucastor dividerus*, the horses *Megahippus, Pliohippus* species *cf. P. tantalus*, *Pliohippus* species, and *Neohipparion* species indicate a Clarendonian Age. This is in sharp contrast to the fauna of the lower sequence at Cedar Mountain (Stewart Spring Fauna, Stirton, 1940) in which the beaver *Monosaulax pansus*, and the horses *Merychippus brevidontus* and *M. californicus* leave little doubt of a Barstovian Age. There are no known faunas of comparable antiquity in beds referred to the Truckee Formation. It would seem, therefore, that the upper portion of the Esmeralda Formation at Cedar Mountain is a possible correlative of the Truckee Formation. That both are Clarendonian seems certain. However, the lack of stratal continuity between the Esmeralda and the Truckee makes any further refinement impractical and possibly misleading.

Yen (1950, p. 181) records the following 18 species from the Fossil Hill locality, which he considers to be the type area of the Truckee Formation: *Sphaerium rugosum* Meek, *Valvata* species *cf. V. incerta* Yen, *V. truckeensis* Yen, *Amnicola truckeensis* Yen, *Fluminicola yatesiana inflata* Yen, *Hydrobia truckeensis* Yen, *Lacunorbis nevadensis* Yen, *Goniobasis sculptilis* (Meek), *Goniobasis* species *cf. G. arnoldiana* Pilsbry, *Lanx undulatus* (Meek), *Gyraulus* species undetermined, *Menetus* species undetermined, *Vorticifex binneyi* (Meek), *Vorticifex tryoni* (Meek), *Vorticifex tryoni concava* (Meek), *Vorticifex tryoni planus* Yen, *Vorticifex globosus* Yen, and *Vorticifex menetoides* Yen.

In addition to those species recorded by Yen, Hannibal (1912) records *Helisoma* (*Perrinilla*) *cordillerana* and *Viviparus turneri* from the "Truckee Lake beds, Nevada."

Comparison of the Cedar Mountain molluscan fauna with that of the type Truckee shows 8 of 29 species, or 36 per cent of the specifically identifiable taxa are identical. Eight of 17 genera are the same.

Fossil molluscs from the type area of the Esmeralda Formation at Silver Peak include *Viviparus turneri*, *Lanx undulatus*, *Valvata truckeensis*, *Vorticifex tryoni*, and an indeterminate species of *Sphaerium* which may be the same as *S. stewartensis*, new species.

PALEOECOLOGY

Pelecypoda

Sphaeriidae.

Sphaerium and *Pisidium*.

The family Sphaeriidae is represented in the Cedar Mountain molluscan fauna by *Sphaerium stewartensis* and *Pisidium leslieae*. The ecologic requirements for the two genera are so similar they do not warrant separate treatment.

The living members of the Sphaeriidae are found in a variety of habitats ranging from deep to shallow water, but the majority prefer water less than 6 feet deep (Pennak, 1953). The Sphaeriidae are tolerant of a wide range of bottom environments. Rock or clay are the only extremes in substrate which they cannot tolerate. Although the sphaeriids prefer water that is somewhat alkaline, they have been recorded from water with a pH of 6.0 (*ibid.*, p. 705).

La Rocque (1960, pp. 20, 21) states that the sphaeriids are not abundant in sediments of lacustrine origin, preferring the running water of streams. Baker (1902) and Pennak (1953) make no such distinction, and the widespread occurrence of these pelecypods in the Cedar Mountain Esmeralda does not support such an inference. The sphaeriids of the Cedar Mountain molluscan fauna have relatively thin, inflated shells, more typical of lake dwellers than of inhabitants of running water.

Gastropoda

Planorbidae.

North American members of this family are littoral, seldom being found at depths greater than 15 feet, with about 6 feet being the optimum. Distribution of individuals within this depth range is determined largely by the food supply. Members of the Planorbidae may be found living in permanent or subpermanent ponds, lakes, and streams. A silty or fine grained sandy substrate where there is an abundance of rooted vegetation is generally the most favorable habitat; however, the Planorbidae are highly tolerant of a wide range of environmental conditions.

The Planorbidae are represented in the Cedar Mountain mollucan fauna by the genera *Planorbis*, *Vorticifex*, *Carinifex*, *Perrinilla*, *Rostroapertura*, and *Promenctus*. Of these 6 genera only 3, *Carinifex*, *Promenctus*, and *Planorbis* are represented by living species and thus offer basis for uniformitarian interpretation of the paleoecology. Beyond the general remarks given above, little may be said of the 3 extinct genera. Since the extinct genera are found in association not only with one another but also with representatives of the extant genera, I believe it reasonable to assume similar habits and habitats for the extinct genera.

Carinifex.

Found principally in a quiet water, littoral habitat with an abundance of rooted vegetation. Exclusively fresh-water. Tolerant of wide temperature variations. The present range of *Carinifex* is western North America, from California east to Wyoming.

Promenetus.

The basis for the ecologic interpretation of *Promenetus kansasensis* is the living species, *P. exacuous* (Say), from the High Plains. Its environment is described by Taylor (1960, p. 59) as follows: "*Promenetus exacuous* is found in shallow, perennial or subpermanent, quiet water bodies, such as ponds, oxbow lakes, marshes, and sloughs or backwaters along streams. It is usually on the submerged vegetation in such habitats." *Promenetus kansasensis* is found only at locality B-2051, in the Barstovian of Stewart Valley. This locality was probably at or near the mouth of a stream, as indicated by the cross-bedding of the enclosing beds. The water could not have been as quiet as that cited by Taylor for *P. exacuous*, which may account for the paucity of specimens.

Planorbis.

Planorbis may be found in streams, ponds, and lakes, preferably where there is an abundance of rooted vegetation and silty or fine grained sandy substrate. It may live in permanent or subpermanent bodies of fresh-water. Species of this genus are highly tolerant of a wide range of environmental conditions.

Planorbis is apparently cosmopolitan in its distribution. As with many other fresh-water gastropods, birds play a major role in the dispersal of *Planorbis*. Passive dispersal of *Planorbis* (as well as *Carinifex* and most other members of the family) is further aided by rafting and by the transport of eggs on the elytra of water beetles. Active dispersal occurs through water channels.

LYMNAEIDAE.

Lymnaea, *Galba*, and *Bulimnea.*

Members of this family are ubiquitous in fresh to brackish water, in either permanent or temporary bodies, from North to South America, eastern Siberia, Greenland, Iceland, and Europe. Species of *Lymnaea*, *Galba*, and *Bulimnea* vary greatly in their habitat preferences. Many species are euryopic. In view of their ability to exist under a wide range of environmental conditions, it is surprising that the Lymnaeidae are not better represented in the Cedar Mountain molluscan fauna.

LANCIDAE.

Lanx.

Lanx may be found in both quiet and running water, clinging to sticks, stems

of water weed, fresh-water crustaceans, stones, or anything that provides a suitable substrate. Although *Lanx* is a pulmonate gastropod, it is also able to extract oxygen directly from the water, thus eliminating the need to come to the surface to respire. Baker (1928, p. 397) records rafting, birds, and the elytra of water beetles as agents of dispersal.

Viviparidae.

Viviparus.

Exclusively fresh-water; found in rivers, streams, lakes, ponds, pools, marshes, backwaters, and bodies of permanent water. *Viviparus* is abundant in areas with heavy growth of aquatic rooted vegetation or concentrations of algae; occasionally it is carnivorous. It is found at various depths, apparently controlled by the availability of food. Respiration is by means of ctenidia, with the mantle serving as a secondary respiratory organ (Prashad, 1928, p. 155). Although reasonably tolerant of substrate, *Viviparus* prefers silty or sandy bottoms.

Methods of passive dispersal available to members of this family are limited. As the young are shed alive after undergoing torsion and development of an embryonic shell, dispersal of an egg mass is impossible. It is the opinion of Prashad (1928, p. 157) that the embryonic shells are too delicate to endure long transport. The older (and larger) individuals are, therefore, the only ones capable of surviving long transport. Successful passive dispersal of *Viviparus*, although possible, is rendered improbable by several factors; their size, their sexual differentiation, and the required size of the transporting agent. As these gastropods are unisexual, successful transport must involve a gravid female or a mature male and female. Shells of the genus generally exhibit sexual dimorphism, with that of the female being larger. As the adults of most species of this genus are large (*V. turneri* reaching a shell height of 2½ inches), the transporting agent would have to be of large size. I believe that transport by birds is, in this instance, highly improbable.

The most plausible, and therefore most widely accepted, means of dispersal for the genus is active dispersal through water channels. Although passive dispersal by rafting in fresh-water is possible, it is unrecorded.

Distribution of the family is essentially world-wide, excepting the polar regions. The distribution of *Viviparus* in the strict sense encompasses Europe, Africa, Asia, Australia, and North America. No North American species of *Viviparus* have been found north of 52° north latitude, and Recent species are further restricted to east of the Rocky Mountains.

Pleuroceridae.

Goniobasis.

Living representatives of this genus are found in waters of varying salinity, ranging from estuarine (species such as *Goniobasis virginica*) to strictly fresh-

water (*G. laurae*). They are generally tolerant of extremely adverse conditions, such as excessive turbidity (La Roque, 1960, p. 27). Respiration is by means of ctenidia.

Dispersal of these pleurocerids is not as easily accomplished as in the Planorbidae or Lancidae. Egg masses are attached to stones, shells, sticks, and on occasion to other individuals of *Goniobasis*. Unlike *Planorbis* or *Lanx* there are no records of *Goniobasis* attaching an egg mass to the elytra of a water beetle. Rafting is a possible means of passive dispersal, but its importance has never been evaluated. *Goniobasis* is not known to be transported by birds. The main method of dispersal, therefore, would appear to be active dispersal through water channels.

VALVATIDAE.

Valvata.

The family Valvatidae is represented in the Cedar Mountain molluscan fauna by at least 2, and possibly 3, distinct species of *Valvata*. Recent forms of *Valvata* are found almost exclusively in large permanent water bodies such as rivers and lakes. A substrate of mixed rock, fine grained sand or silt is preferred, although almost any substrate is tolerated.

It is significant that *Valvata* is almost universally intolerant of waters having a pH of less than 7.0. This supports the hypothesis that the lacustrine sediments of the Cedar Mountain Esmeralda Formation were deposited in alkaline waters.

Dispersal of this genus is usually through water channels. Passive dispersal, primarily through the agency of birds, is probably of secondary importance. I know of no recorded instance of egg masses being transported on the elytra of water beetles.

AMNICOLIDAE.

Amnicola.

Species of this genus are found clinging to stems or leaves of aquatic plants, bathed by a gentle current. In contrast to *Valvata*, *Amnicola* is tolerant of a wide range of hydrogen ion concentrations, from a pH of 5.7 to a pH of 8.3 (Pennak, 1953, p. 681). It is surprising that only one recognizable specimen of *Amnicola* was found in the Cedar Mountain Esmeralda as it is abundant in the Truckee beds where much the same environment prevailed. Dispersal of this genus is similar to that of *Valvata*.

In summary, the Cedar Mountain molluscan fauna inhabited a large permanent lake. Their general preference was for shallow, relatively quiet water, with an abundance of rooted aquatic vegetation. The climate was more equable then than now, a fact well documented by associated fossil flora.

Drainage

It is my opinion that the Stewart and Ione basins drained externally during the Barstovian and Clarendonian. If the drainage had been predominantly internal, the resultant concentration of dissolved salts would have precluded the presence of such exclusively fresh-water genera as *Carinifex* and *Viviparus*. Both of these genera, however, are represented by numerous individuals at many localities in both basins.

Additional support for a hypothesis of external drainage is provided by the hydrogen ion concentration tolerance of the molluscan fauna. An excessive concentration of dissolved carbonates (greater than a pH of 8.0) would be intolerable to most fresh-water gastropods. A noted exception to this is *Amnicola*, which has been recorded from water with a pH of 8.3. Certainly carbonates in solution were available for concentration, and without external drainage a high concentration would be expected. The surrounding mountain ranges, which served as a major source of sediment for the Stewart and Ione basins, have extensive areas of Mesozoic limestones which probably would have provided dissolved carbonates throughout the Tertiary depositional history of these basins. At the same time we may assume that the water of these basins was slightly alkaline, as such aggregations of molluscs, both in number of species and individuals, are atypical of waters with a pH of less than 7.0. Additional evidence is provided by the presence of *Valvata*, which cannot tolerate water with a pH of less than 7.0.

SYSTEMATIC PALEONTOLOGY

Class PELECYPODA

Family Sphaeriidae

Genus **Sphaerium** Scopoli

Type *Tellina cornea* Linnaeus, 1758

Sphaerium stewartensis Firby, new species.

(Figures 12, 15, 17, 18.)

Description. Shell ovoid; beaks almost central, slightly anterior; sculpture of closely spaced growth lines, more prominent dorsally than ventrally; right valve with single triangular arched cardinal tooth anterior to beak; two elongate anterior lateral teeth, two low elongate posterior lateral teeth; posterior lateral teeth one-third longer than anterior lateral teeth; left valve with small single pointed cardinal tooth, single prominent anterior lateral, single prominent posterior lateral; posterior margin flatter than anterior margin.

Holotype *UCMP* 37869. Paratypes *UCMP* 37870, 37871; *CAS* 12757, 12758.

Measurements

Length	Height	Length	Height
10.8 mm. right valve	10.3 mm.	12.0 mm. right valve	11.0 mm.
11.7 mm. " "	11.3 mm.	12.9 mm. " "	12.2 mm.

9.9 mm. " "	9.9 mm.	9.3 mm. " "	8.8 mm.
10.5 mm. left valve	10.1 mm.	10.8 mm. left valve	10.1 mm.

Discussion. This species resembles *Sphaerium rugosum* Meek, 1877, but differs in having the beaks more central, a less trigonal outline, and heavier lateral teeth. The less pronounced costae of *S. stewartensis* may be due, in part, to a greater amount of available carbonates. *Sphaerium stewartensis* is larger than *S. rugosum*, being closest in size to *S. malheurensis* Henderson and Rodeck, 1934, from the Pliocene of Oregon. *Sphaerium stewartensis* is common throughout the Cedar Mountain Esmeralda beds, occurring in beds of Barstovian and Clarendonian age.

Occurrence. The type specimen is from *UCMP* B-2051, Barstovian of Stewart Valley. Preservation of the shells is excellent at this locality, and numerous complete left and right valves were collected. Other localities: *UCMP* B-2052, B-8305, B-8306, B-8307, B-8310, B-8314, B-8315, B-8317, B-8318, B-8321, B-8328, B-8329, B-8331, B-8335.

Genus **Pisidium** Pfeiffer, 1821
Type *Tellina amnica* Müller, 1774

Pisidium leslieae Firby, new species.
(Figures 2, 3, 6, 7, 10.)

Description. Shell trigonal, inflated; beaks high, two-thirds distant from anterior margin; surface of shell with prominent concentric sculpture, regularly spaced, uniform in size near beak, stronger towards margin; hinge arched, with cardinal area almost straight; posterior margin slightly curved; right valve with two posterior and two anterior laterals, posterior laterals slightly more massive than anterior; cavity between both posterior and anterior laterals deep; dorsal laterals low, ventral laterals roundly pointed; crescent-shaped shallow ligamental groove from cardinal tooth extends anteriorly to, but does not meet, anterior lateral; 2 triangular, pointed cardinal teeth; anterior cardinal extended to form low ridge which joins anterior lateral, forming ventral boundary of the anterior ligamental groove.

Holotype *UCMP* 37872. Paratypes *UCMP* 37873, 37874; *CAS* 12759, 12760.

Measurements

Length	Height	Length	Height
6.4 mm. right valve	6.2 mm.	5.9 mm. right valve	6.4 mm.
7.1 mm. " "	6.9 mm.	6.7 mm. left valve	6.4 mm.
6.2 mm. left valve	5.9 mm.	6.0 mm. " "	5.6 mm.
4.1 mm. " "	3.5 mm.		

Discussion. Numerous well preserved specimens were found in Barstovian beds in Stewart Valley. This form is like *Pisidium curvatum* Hanna, 1923, from the late Miocene of Sonoma County, California, but differs from it by having

the cardinal tooth directly under the beak, and more strongly curved anterior and posterior margins. It is proportionally shorter than *P. curvatum* in height to width ratio. That it is slightly more inflated than *P. curvatum* is of little taxonomic value, as this feature is largely controlled by environment and may vary considerably within a species.

OCCURRENCE. Type locality *UCMP* B-2051, Barstovian of Stewart Valley. Other localities: *UCMP* B-8317, B-8318, B-8325, B-8326.

Class GASTROPODA
Family PLANORBIDAE
Genus **Vorticifex** Meek, 1870
Type *Carinifex* (*Vorticifex*) *tryoni* Meek, 1870
(= *Choanomphalus* (*Carinifex*) *tryoni* Fischer, 1887)

Vorticifex stewartensis Firby, new species.
(Figures 1, 5, 9.)

DESCRIPTION. Shell ultradextral; whorls 4 to 4½, rapidly increasing in size, flatly convex; sculpture of strong axial ribs; body whorl with rounded shoulder, flattened sides obscurely angulate at base; body whorl does not descend; spire depressed approximately one-sixth total shell height; sutures deep, impressed; aperture roundly sub-quadrate; umbilicus wide, one-half diameter of shell, deep, funicular, showing preceding whorls.

HOLOTYPE *UCMP* 37875. PARATYPES *UCMP* 37876, 37877; *CAS* 12761.

MEASUREMENTS

Diameter	Height
12.3 mm.	5.8 mm.
12.8 mm.	5.7 mm.
12.0 mm.	5.1 mm.

DISCUSSION. This form resembles *Vorticifex menetoides* Yen, 1950, but differs in being distinctly concave in apical view, owing to the depressed spire, and has a much wider umbilicus. *Vorticifex stewartensis* is found with *V. tryoni* and *V. binneyi*, and is distinctly larger and more robust.

OCCURRENCE. Type locality *UCMP* B-2051. Other localities *UCMP* B-8326, B-8332.

Genus **Planorbis** Geoffrey, 1767
Type *Helix Planorbis* Linnaeus, 1758

Planorbis webbi Firby, new species.
(Figures 11, 14.)

DESCRIPTION. Shell large for genus, discoidal; spire flat or slightly raised; 4½ to 5½ whorls; whorls flatly convex above, rounded below; periphery of whorls obscurely angulate; last one-quarter of last whorl slightly descending, ex-

panded, becoming flatly concave above aperture; sculpture of regularly spaced, prominent, prosocline axial ribs; aperture cardiform, deflected; umbilicus one-third diameter of shell, funicular, deep, exposing early whorls.

Holotype *UCMP* 37878. Paratypes *UCMP* 37879; *CAS* 12762.

Measurements

Maximum diameter	Height	Maximum diameter	Height
17.4 mm.	7.5 mm.	15.2 mm.	6.8 mm.
15.2 mm.	6.8 mm.	15.0 mm.	8.0 mm.
15.0 mm.	6.2 mm.	14.3 mm.	7.0 mm.
13.7 mm.	7.4 mm.	13.3 mm.	5.4 mm.

Discussion. *Planorbis webbi* appears to be close to *P. utahensis* Meek, 1877, from the Bridger group of southern Wyoming. *Planorbis webbi* is distinguished by the slight concavity on the ventral surface of the body whorl just over the aperture, and the expansion of the last one-quarter of the body whorl. Only 9 specimens were found, preserved as casts.

Occurrence. Type locality *UCMP* B-8333, Clarendonian. Only locality.

Family Lymnaeidae

Genus **Bulimnea** Haldeman, 1841

Type *Bulimnea megasoma* (Say)

Bulimnea webbi Firby, new species.

(Figures 4, 8.)

Description. Shell thin, turbinate; spire high, slightly over one-third shell height; whorls rapidly enlarging, becoming increasingly more convex abapically, sutures well defined, deeply impressed to form a shoulder; body whorl inflated; aperture ovoid, slightly oblique; inner lip with thickened parietal callus; umbilicus reduced to a small chink; sculpture not known.

Holotype *UCMP* 37880. Paratypes *UCMP* 37881; *CAS* 12763.

Measurements

Height	Maximum diameter	Height of aperture
24.8 mm.	15.6 mm.	13.5 mm.
27.5 mm.	11.8 mm.	14.0 mm.
16.8 mm.	11.5 mm.	10.8 mm.

Discussion. *Bulimnea webbi* is strongly reminiscent of *B. megasoma* (Say) in size and proportion. It differs in having a more inflated body whorl and less acute spire angle. The fossils are preserved as opalized internal casts, with fragments of shell material adhering in small patches, especially portions of the parietal callus. *Bulimnea webbi* has a much higher spire and a much less inflated body whorl than *Radix junturae* Taylor, which occurs stratigraphically higher.

Occurrence. Type locality *UCMP* B-8325, Barstovian. Only locality.

Family PLEUROCERIDAE
Genus **Goniobasis** Lea, 1862
Type *Melania olivula* Conrad, 1834

Goniobasis reticulata Firby, new species.
(Figures 13, 16.)

DESCRIPTION. Shell imperforate, 6 to 8 whorls; spire high, four-fifths total shell height; whorls convex, with marked reticulate sculpture formed by strong, regularly spaced axial ribs intersecting slightly less pronounced spiral cords; 25 to 35 axial ribs on body whorl, ceasing abruptly at basal portion of body whorl; basal portion of body whorl concave, delineated by strong spiral cord, 4 to 5 inferior spiral cords on basal portion of body whorl; sculpture of threadlike, very closely spaced growth lines parallel to axial ribs for entire length of shell; aperture ovoid, slightly produced abapically; inner lip reflexed, callused; outer lip not expanded, continuous; sutures distinct, grooved; columella smooth; angle of spire 20° to 22°.

HOLOTYPE *UCMP* 37882. PARATYPES *UCMP* 37883, 37884; *CAS* 12764.

MEASUREMENTS

Height	Maximum diameter
9.9 mm. (3 whorls)	5.5 mm. (type)
13.9 mm. (4 ")	5.5 mm.
17.0 mm. (4½ ")	7.2 mm.
16.2 mm. (4 ")	6.8 mm.
6.7 mm. (5½ ")	3.3 mm.
6.6 mm. (5 ")	3.4 mm.

DISCUSSION. This species has features in common with both *G. simpsoni* and *G. sculptilis* of Meek, from the Kaw-soh Mountains. The concavity of the abapical portion of the body whorl and the anterior production of the aperture distinguish *G. reticulata* from *G. simpsoni*. Greater convexity of whorls, lesser spire angle, stronger spiral sculpture and abrupt cessation of axial ribs on basal portion of the body whorl distinguish it from *G. sculptilis*.

OCCURRENCE. Type locality *UCMP* B-2051, Barstovian. Other localities: *UCMP* B-2050, B-8301, B-8305, B-8309, B-8310, B-8311, B-8312, B-8315, B-8317, B-8318, B-8321, B-8322, B-8329, B-8332, B-8335, B-8337.

Goniobasis leslieae Firby, new species.
(Figures 19, 20.)

DESCRIPTION. Shell imperforate, elongate, conical; spire high, gradually tapered to apex, with spire angle of 12° to 16°; 8 to 10 markedly convex whorls; early whorls with sculpture of slightly raised axial ribs, intersected by faint spiral threads; apical whorl distinguished by a peripheral angulation two-thirds of distance from preceding suture; whorls marked by opisthocyrt, crowded,

threadlike growth lines, becoming sigmoidal on body whorl; aperture ovoid, slightly oblique; inner lip reflexed, callused; outer lip not expanded, continuous; sutures linear, slightly grooved; basal portion of body whorl convex.

Holotype *UCMP* 37885. Paratypes *UCMP* 37886, 37887; *CAS* 12765.

Measurements

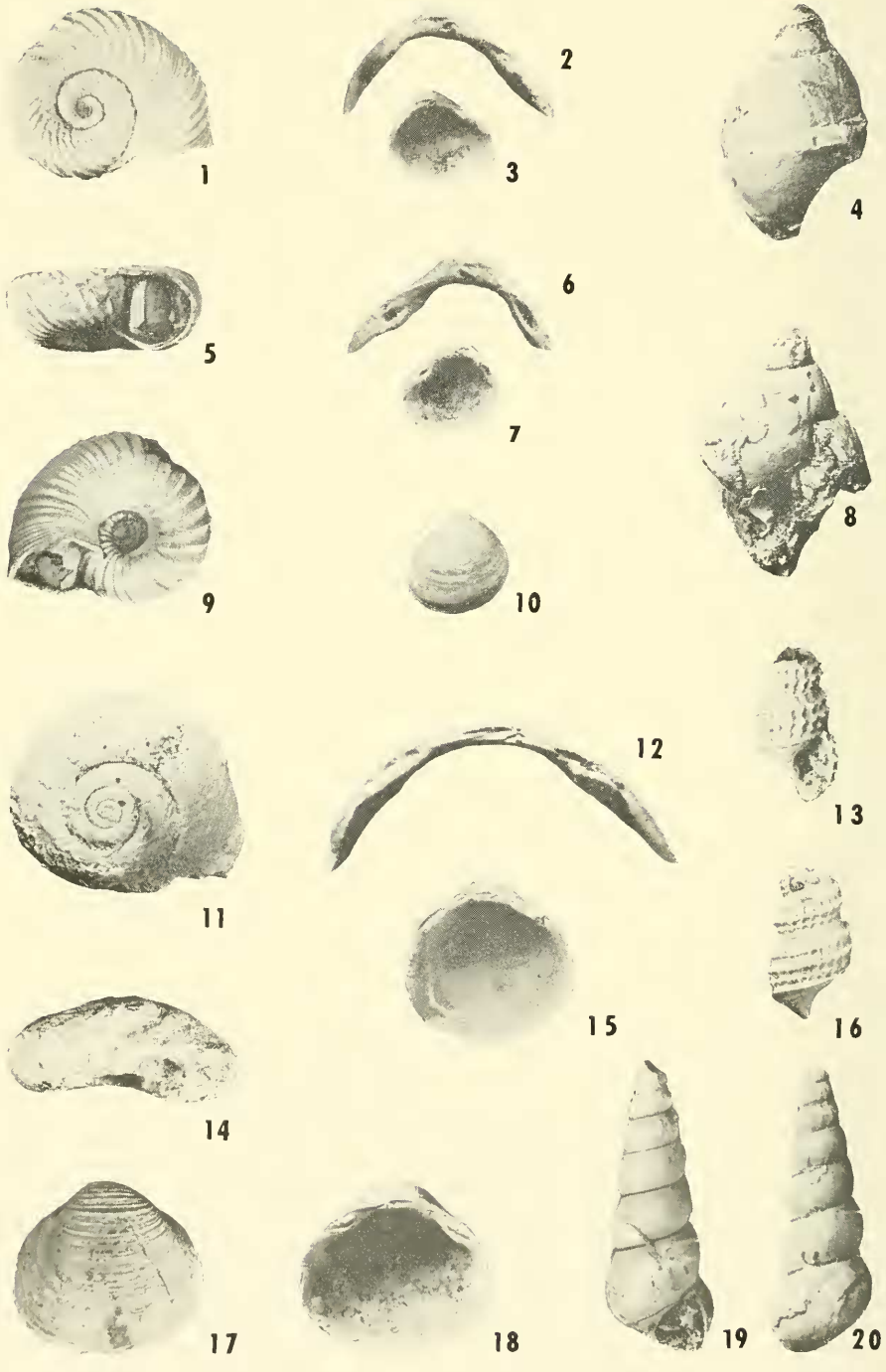
Height	Maximum diameter
15.6 mm. (8 whorls, apex broken)	5.6 mm.
16.5 mm. (9 " " ")	5.8 mm.
8.5 mm. (8 " complete)	3.2 mm.

Discussion. *Goniobasis lesliae* is similar to *G. simpsoni* Meek, 1877, but is slenderer, with a spire angle 10° less than that reported by Meek. Sculpture of specimens from the type locality is fairly uniform, with only minor variations in the height and persistence of the axial ribs. Specimens from the type locality retain the shell, and show surface ornamentation clearly.

Occurrence. Type locality *UCMP* B-2051, Barstovian. Only locality.

Localities	Barstovian																					Clarendonian																				
Molluscan Fauna	B-2050	B-2051	B-2053	B-8300	B-8301	B-8302	B-8303	B-8304	B-8305	B-8306	B-8317	B-8318	B-8324	B-8325	B-8326	B-8327	B-8328	B-8329	B-8334	B-8335	B-8336	B-8337	B-2052	B-8307	B-8308	B-8309	B-8310	B-8311	B-8312	B-8313	B-8314	B-8315	B-8316	B-8319	B-8320	B-8321	B-8322	B-8323	B-8330	B-8331	B-8332	B-8333
Pelecypoda																																											
Sphaerium stewartensis, new species	×								×	×	×	×					×	×		×			×	×			×		?		×	×		?	?	×				×		
Sphaerium species						×	×																					×														
Pisidium leslieae, new species	×										×	×		×	×																												
Pisidium leslieae?										×						×	×				×																						
Gastropoda																																										
Carinifex malheurensis																							×								?									×	×	×
Carinifex species						×																																				
Perrinilla cordillerana	×			×	×			×			?												×	×				?	×	×	×	×	?	×		×				×	×	×
Perrinilla (?) species																													×													
Promenetus kansasensis	×																																									
Rostroapertura mawbyi			×		×																																				
Rostroapertura species							×																																			
Vorticifex tryoni		×			?				×	×	×	×	×	×	×	?	×	?			×		×	×		×					×	×	?		?	×	×				×	
Vorticifex binneyi		×								×	×		×	×	×						?			×																	×	
Vorticifex globosus																																×										
Vorticifex stewartensis, new species		×								×																×															×	
Vorticifex species compare *V. tryoni*													×						×														×									
Vorticifex species																×																										
Planorbis webbi, new species																																										×
Planorbis (?) species																									×																	
Radix junturae									×																																	
Bulimnea webbi, new species														×																												
Valvata truckeensis									×											×																						
Valvata incerta		×										×																													×	

Valvata species																														×											
Viviparus turneri	×	×						×		×	×	×					?	×		×		×							×					×				×		×	
Viviparus species																	×			×																					
Goniobasis reticulata, new species	×	×			×	?			×		×	×			?			×		×		×			×	×	×	×			×		?		×	×				×	×
Goniobasis leslieae, new species		×																																							
Goniobasis species				×	×				×										×																				×		
Lymnaea vetusta (?)		×																																							
Galba species																							×																		
Lanx undulatus												×					×																		×						
Lanx species																	×																								
Amnicola species, compare *A. truckeensis*																														×											


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

APPENDIX

Register of Localities

All coordinates refer to United States Geological Survey Tonopah Quadrangle, scale 1:250,000, 1959 edition, Nye and Mineral counties, Nevada.

Locality:

B-2050: N.W. ¼ section 21, Range 38 E., Township 9 N., Nye County. Along county road to Mina 5.6 miles, west from junction with Nevada State Highway 89, approximately 500 feet north of road.

Lithology: Well-indurated, poorly bedded fine to medium grained tuffaceous sandstone, light grey to blue grey, weathering to brown.

Age: Barstovian.

B-2051: S.E. ¼ of S.E. ¼ section 20, Range 36 E., Township 9 N., Mineral County. East side of Stewart Valley road, adjacent to road, 11.5 miles north from junction with county road to Mina.

Lithology: Sequence of fore-set beds of calcareous cemented sandstone, vitric ash, tuff, thin beds of pebble conglomerate.

Age: Barstovian. Associated fossil mammals.

B-2052: Center section 15, Range 38 E., Township 8 N., Nye County. West from junction with Nevada State Highway 89, 2.5 miles along county road to Mina, just south of road in low bluff.

Lithology: Moderately well-indurated grey tuffaceous sandstone, well bedded.

Age: Clarendonian.

←

Figures 1, 5, 9. *Vorticifex stewartensis* Firby, new species, ×2. Holotype *UCMP* no. 37875, locality B-2051.

Figures 2, 3, 10. *Pisidium leslieae* Firby, new species, left valve.

Figures 3, 10, ×2; Figure 2, ×5. Paratype *UCMP* no. 37873, locality B-2051.

Figures 6, 7. *Pisidium leslieae* Firby, new species, right valve.

Figure 7, ×2; Figure 6, ×5. Holotype *UCMP* no. 37872, locality B-2051.

Figures 4, 8. *Bulimnea webbi* Firby, new species, ×2. Holotype *UCMP* no. 37880, locality B-8325.

Figures 11, 14. *Planorbis webbi* Firby, new species, ×2. Holotype *UCMP* no. 37878, locality B-8333.

Figures 12, 15. *Sphaerium stewartensis* Firby, new species, left valve.

Figure 15, ×5; Figure 12, ×2. Paratype *UCMP* no. 37870, locality B-2051.

Figures 17, 18. *Sphaerium stewartensis* Firby, new species, right valve, ×2. Holotype *UCMP* no. 37869, locality B-2051.

Figures 13, 16. *Goniobasis reticulata* Firby, new species, ×2. Holotype *UCMP* no. 37882, locality B-2051.

Figures 19, 20. *Goniobasis leslieae* Firby, new species, ×2. Holotype *UCMP* no. 37885, locality B-2051.

B-2053: S.W. corner of S.E. ¼ section 33, Range 36 E., Township 9 N., Mineral County. Approximately 300 feet north of Stewart Springs road, 0.3 miles up road from junction with Stewart Valley road. This junction is 9.8 miles north along Stewart Valley road from intersection with county road to Mina.

Lithology: Coarse grained well-indurated tuffaceous sandstone, indistinctly bedded.

Age: Barstovian. Associated fossil mammals.

B-8300: N.E. ¼ section 22, Range 36 E., Township 9 N., Mineral County. In canyon on east side of abandoned mining road between Warrior Mine and Stewart Valley, 5.3 miles west along road from Warrior Mine. Up west fork of canyon approximately ¼ mile, on top of ridge, west side of canyon.

Lithology: Well-indurated fine to medium grained grey to brown sandstone, cemented by $CaCO_3$.

Age: Barstovian.

B-8301: N.W. ¼ of S.E. ¼ section 22, Range 36 E., Township 9 N., Mineral County. Approximately ½ mile up west fork of canyon described above, near top of west wall.

Lithology: Moderately well-indurated, well-bedded tuffaceous sandstone.

Age: Barstovian.

B-8302: N.W. ¼ section 23, Range 36 E., Township 9 N., Mineral County. Approximately 400 yards up canyon described above, in east wall of canyon.

Lithology: Well-bedded diatomite.

Age: Barstovian.

B-8303: N.E. ¼ section 23, Range 36 E., Township 9 N., Mineral County. In east side of canyon described above, just past low diatomite ridge, east wall of canyon.

Lithology: Grey tuffaceous sandstone interbedded with thin beds of vitric ash.

Age: Barstovian.

B-8304: S.E. ¼ section 22, Range 36 E., Township 9 N., Mineral County. West fork of canyon described for *UCMP* locality B-8300. One mile up canyon from road, 50 feet above canyon floor in west wall.

Lithology: Coarse, well-indurated sandstone and conglomerate, cemented by $CaCO_3$.

Age: Barstovian.

B-8305: Center section 22, Range 36 E., Township 9 N., Mineral County. West fork of canyon described for *UCMP* locality B-8300, ¾ mile up canyon, top of ridge west side of canyon.

Lithology: Thin beds of well-indurated limestone capping tuffaceous sandstone.

Age: Barstovian.

B-8306: N.E. ¼ section 29, Range 36 E., Township 9 N., Mineral County. In basal portion of high cliff on north side of canyon, 11.2 miles from junction of Stewart Valley road with county road to Mina and 0.3 miles south of *UCMP* locality B-2051.

Lithology: Sequence of fine grained, poorly bedded tuffaceous sandstone, tuff, conglomerate, massive grey limestone, diatomite, and well-bedded "paper shale."

Age: Barstovian.

B-8307: N.E. ¼ section 11, Range 38 E., Township 8 N., Nye County. East of Nevada State Highway 89, 1.6 miles north along road from junction with county road to Mina and 5.2 miles along road from *UCMP* locality B-2052.

Lithology: Well-bedded, moderately well-indurated tuffaceous sandstone cemented by $CaCO_3$.

Age: Clarendonian. Associated fossil mammals.

B-8308: N.E. ¼ section 9, Range 38 E., Township 8 N., Nye County. Top of small butte approximately 1.5 miles W.S.W. of *UCMP* locality B-8307.

Lithology: Resistant dark grey massive limestone.

Age: Clarendonian?

B-8309: N.W. ¼ section 15, Range 38 E., Township 8 N., Nye County. In south side of cut-bank, approximately ½ mile N. 50° W. from *UCMP* locality B-2052.

Lithology: Fine grained grey tuffaceous sandstone, 30 feet thick, cemented by $CaCO_3$.

Age: Clarendonian.

B-8310: S.E. ¼ of N.E. ¼ section 15, Range 38 E., Township 8 N., Nye County. In south side of cut-bank, approximately ¼ mile downstream from *UCMP* locality B-8309.

Lithology: Grey, poorly bedded tuffaceous sandstone, weakly cemented by $CaCO_3$.

Age: Clarendonian.

B-8311: S.W. ¼ of S.W. ¼ section 15, Range 38 E., Township 8 N., Nye County. West 2.8 miles along county road to Mina from junction with Nevada State Highway 89. At base of low hill 1,800 feet south of road.

Lithology: Small lenticular body of diatomite.

Age: Clarendonian.

B-8312: S.E. ¼ of S.W. ¼ section 15, Range 38 E., Township 8 N., Nye County. Locality essentially the same as for *UCMP* locality B-8311, but on east flank of same low hill.

Lithology: Well-bedded impure diatomite.

Age: Clarendonian.

B-8313: N.W. ¼ section 21, Range 38 E., Township 8 N., Nye County. Top of butte on north side of county road to Mina, approximately 4 miles west along road from junction with Nevada State Highway 89.

Lithology: Massive grey limestone.

Age: Clarendonian.

B-8314: Center N.W. ¼ section 21, Range 38 E., Township 8 N., Nye County. Approximately 4 miles west along county road to Mina from junction with Nevada State Highway 89. At head of gully approximately 1,000 feet south of road.

Lithology: Medium to coarse grained moderately well-bedded tuffaceous sandstone.

Age: Clarendonian?

B-8315: Center section 21, Range 38 E., Township 8 N., Nye County. In south bank of small wash ½ mile S.E. of *UCMP* locality B-8314.

Lithology: Coarse grained, poorly sorted tuffaceous sandstone.

Age: Clarendonian.

B-8316: N.E. ¼ section 21, Range 38 E., Township 8 N., Nye County. In cut-bank on north side of east-west trending wash, ¾ mile S. 32° E. from *UCMP* locality B-8314.

Lithology: Sandy limestone, containing numerous sub-angular pebbles less than ½ inch in diameter.

Age: Clarendonian.

B-8317: S.E. ¼ of N.W. ¼ section 29, Range 36 E., Township 9 N., Mineral County. In canyon west of Stewart Valley road, ¼ mile S.W. of *UCMP* locality B-2051.

Lithology: Fine grained tuffaceous sandstone with small lenticular bodies of limestone.

Age: Barstovian. Associated fossil mammals.

B-8318: N.E. ¼ section 4, Range 36 E., Township 8 N., Mineral County. Approximately 200 yards south of Stewart Springs road described for *UCMP* locality B-2053.

Lithology: Grey to brown fine grained sandstone, well-bedded, cemented by $CaCO_3$.

Age: Barstovian.

B-8319: S.E. corner of N.W. ¼ section 15, Range 38 E., Township 8 N., Nye

County. West 2.5 miles along county road to Mina from junction with Nevada State Highway 89. Approximately 300 feet north of road.

Lithology: Grey, well-bedded tuffaceous sandstone, cemented by $CaCO_3$. Sandstone contains numerous concretions.

Age: Clarendonian.

B-8320: N.E. corner of N.W. ¼ section 14, Range 38 E., Township 8 N., Nye County. Approximately 100 yards west of junction of county road to Mina and Nevada State Highway 89, in west flank of low hill near road.

Lithology: Medium to coarse grained well-indurated tuffaceous sandstone, moderately well bedded.

Age: Clarendonian.

B-8321: S.W. ¼ section 11, Range 38 E., Township 8 N., Nye County. Approximately 2 miles along county road to Mina from junction with Nevada State Highway 89, north of road.

Lithology: Well-bedded, moderately well-indurated tuffaceous sandstone cemented by $CaCO_3$.

Age: Clarendonian.

B-8322: N.E. ¼ of N.W. ¼ section 28, Range 38 E., Township 8 N., Nye County. Approximately 2 miles south of county road to Mina and 1 mile north of abandoned road known locally as "South Road," on south side of east-west trending canyon.

Lithology: Well-bedded diatomite, 20 feet thick, overlying grey sandy limestone.

Age: Clarendonian.

B-8323: S.W. ¼ section 21, Range 38 E., Township 8 N., Nye County. In same canyon as *UCMP* locality B-8322, but ½ mile south.

Lithology: Poorly sorted, indistinctly bedded tuffaceous sandstone, cemented by $CaCO_3$, moderately well-indurated.

Age: Clarendonian? Associated fossil mammals.

B-8324: N.W. ¼ section 29, Range 36 E., Township 9 N., Mineral County. West side of Stewart Valley road, 11.2 miles from junction with county road to Mina. Approximately ½ mile west up canyon, near top of low ridge, north side of canyon.

Lithology: Coarse grained, poorly sorted grey sandstone cemented by $CaCO_3$, above a brown unconsolidated silt.

Age: Barstovian. Associated fossil mammals.

B-8325: N.W. ¼ section 29, Range 36 E., Township 9 N., Mineral County. Same geographic location as *UCMP* locality B-8324, but 20 feet higher in the section.

Lithology: Brown, moderately well-sorted medium grained tuffaceous sandstone.

Age: Barstovian.

B-8326: S.W. ¼ section 29, Range 36 E., Township 8 N., Mineral County. South side of canyon to west of Stewart Valley road, 11.2 miles north along road from junction with county road to Mina. In base of small butte ½ mile up canyon.

Lithology: Brown, medium grained tuffaceous sandstone, cemented by $CaCO_3$.

Age: Barstovian. Associated fossil mammals.

B-8327: S.E. ¼ of N.W. ¼ section 32, Range 38 E., Township 8 N., Nye County. Immediately south of "South Road," 3.5 miles west along road from junction with a ½ mile long road connecting "South Road" with county road to Mina.

Lithology: Coarse grained grey tuffaceous sandstone, cemented by $CaCO_3$, interbedded with diatomite.

Age: Barstovian.

B-8328: S.W. ¼ section 29, Range 38 E., Township 8 N., Nye County. On a bearing of N. 25° W., 4,920 feet from *UCMP* locality B-8326 towards point of a high, isolated, lava capped butte.

Lithology: Well-indurated, moderately well-bedded grey, sandy limestone.

Age: Barstovian.

B-8329: S.W. ¼ section 29, Range 38 E., Township 8 N., Nye County. On a bearing of N. 25° W., 5,250 feet from *UCMP* locality B-8326 towards point of same lava capped butte as above.

Lithology: Well-indurated, well-bedded, grey sandy limestone.

Age: Barstovian. Associated fossil mammals.

B-8330: S.W. ¼ of N.W. ¼ section 29, Range 38 E., Township 8 N., Nye County. On a bearing of N. 20° W., 8,200 feet from *UCMP* locality B-8326. Stratigraphically and unconformably above a fine grained brown siltstone.

Lithology: Grey, medium to fine grained tuffaceous sandstone, cemented by $CaCO_3$.

Age: Clarendonian.

B-8331: Center of boundary between sections 28 and 29, Range 38 E., Township 8 N., Nye County. South of "South Road" 200 feet, 2½ miles west along "South Road" from junction with road connecting with county road to Mina.

Lithology: Grey, medium to fine grained tuffaceous sandstone, cemented by $CaCO_3$.

Age: Clarendonian.

B-8332: Center section 29, Range 38 E., Township 8 N., Nye County. One-half mile north of "South Road," 3 miles west along road from junction with short road connecting with county road to Mina.

Lithology: Moderately well-bedded grey sandy limestone.

Age: Clarendonian. Associated fossil mammals.

B-8333: S.W. ¼ of N.W. ¼ section 22, Range 38 E., Township 8 N., Nye County. Approximately ½ mile north of "South Road," slightly west of north from *UCMP* locality B-8331. Stratigraphically the same as *UCMP* locality B-8332.

Lithology: Medium to fine grained, grey tuffaceous sandstone interbedded with lighter grey sandy limestone.

Age: Clarendonian. Associated fossil mammals.

B-8334: S.E. ¼ of N.E. ¼ section 21, Range 36 E., Township 8 N., Mineral County. In low bluff on east side of Stewart Valley road, 3.1 miles south of intersection of Stewart Valley road with road to Stewart Springs.

Lithology: Grey, well-bedded limestone and fine grained tuffaceous sandstones.

Age: Barstovian.

B-8335: S.E. ¼ of N.E. ¼ section 4, Range 36 E., Township 8 N., Mineral County. In north-south trending wash, ¼ mile south from road to Stewart Springs and approximately ¼ mile east of Stewart Valley road.

Lithology: Extremely well-bedded, well-indurated, grey tuffaceous sandstone, cemented by $CaCO_3$.

Age: Barstovian.

B-8336: N.E. ¼ of S.E. ¼ section 9, Range 36 E., Township 8 N., Mineral County. In east bank of canyon, approximately 200 yards east of Stewart Valley road. Canyon is 1.4 miles south of intersection of Stewart Valley road with Stewart Springs road.

Lithology: Extremely well-bedded green to grey "paper shale."

Age: Barstovian.

B-8337: N.W. ¼ section 4, Range 36 E., Township 8 N., Mineral County. South bank of canyon west of Stewart Valley road approximately ¼ mile, due west of *UCMP* locality B-8318.

Lithology: Grey, poorly bedded fine grained tuffaceous sandstone, weakly cemented by $CaCO_3$.

Age: Barstovian. Associated fossil mammals.

REFERENCES

Baker, F. C.
1945. The molluscan family Planorbidae. University of Illinois Press, 530 pp., 141 pl.

Buwalda, J. P.
1914. Tertiary mammal beds of Stewart and Ione valleys in west-central Nevada. University of California Publications in Geology, vol. 8, no. 19, pp. 335–363.

Firby, J. R.
1963. A new genus of planorbid gastropod from the Esmeralda Formation of Nevada. Journal of Palentology, vol. 37, no. 5, pp. 1120–1122, 7 text figs.

Hanna, G D.
1923. Upper Miocene lacustrine mollusks from Sonoma County, California. Proceedings of the California Academy of Sciences, 4th ser., vol. 12, no. 3, pp. 31–41, pl. 1–3.

Hannibal, H.
1912. A synopsis of the Recent and Tertiary freshwater mollusca of the California Province. Proceedings of the Malacological Society of London, vol. 10, pts. 1 and 2, pp. 112–211, 4 pl.

Henderson, J.
1935. Fossil non-marine mollusca of North America. Geological Society of America Special Paper, no. 3, pp. 1–313.

Henderson, J., and H. C. Rodeck
1934. Some new species of Pliocene mollusca from eastern Oregon. Journal of Paleontology, vol. 8, pp. 264–268, 1 pl.

Hensiiaw, P. C.
1942. A Tertiary mammalian fauna from the San Antonio Mountains near Tonopah, Nevada. Carnegie Institution of Washington Publication 530, pp. 79–168, 11 pl.

La Rocque, A.
1960. Molluscan faunas of the Flagstaff Formation of central Utah. Geological Society of America Memoir 78, pp. 1–100, pl. 1–4.

Macdonald, J. R.
1956. A new Clarendonian mammalian fauna from the Truckee Formation of Nevada. Journal of Paleontology, vol. 30, no. 1.

Meek, F. B.
1870. Descriptions of fossils collected by the U. S. Geological Survey under the charge of Clarence King, Esq. Philadelphia Academy of Natural Sciences, Proceedings, vol. 22, pp. 56–64.
1871. Preliminary paleontological report, consisting of lists of fossils, with descriptions of some new types, etc. United States Geological and Geographical Survey Territories [Hayden Survey], 4th Ann. Report, pp. 287–318.
1877. U. S. Geol. Exploration of the 40th Parallel. [King Survey], vol. 4, pt. 1, pp. 1–197, 17 pl.

Merriam, J. C.
1916. Tertiary vertebrate fauna from the Cedar Mountain region of western Nevada. University of California Publications in Geology, vol. 9, no. 13, pp. 161–198, pl. 8.

Pennak, R. W.
1953. Fresh-water invertebrates of the United States. Ronald Press Co., New York, 769 pp.

Prashad, B.
1928. Recent and fossil Viviparidae. Indian Museum Memoirs, vol. 8, no. 4, pp. 153–251, pl. 19.

ROSS, D. C.
1961. Geology and mineral deposits of Mineral County, Nevada. Nevada Bureau of Mines, Bulletin no. 58, pp. 1–98, pl. 1–2.

STIRTON, R. A.
1940. The Nevada Miocene and Pliocene faunas as faunal units. Proceedings of the Sixth Pacific Science Congress, pp. 627–640.

TAYLOR, D. W.
1960. Late Cenozoic molluscan faunas from the High Plains. United States Geological Survey Professional Paper 337, pp. 1–94, pl. 1–4.
1963. Mollusks of the Black Butte local fauna. Transactions of the American Philosophical Society, vol. 53, pt. 1, no. 3, pp. 35–41, pl. 2.

TURNER, H. W.
1900. The Esmeralda Formation, a fresh-water lake deposit in Nevada. United States Geological Survey 21st Annual Report, pt. 2, pp. 191–224, pl. 24–31.

WOOD, H. E., *et al.*
1941. Nomenclature and correlation of the North American continental Tertiary. Geological Society of America Bulletin, vol. 52, pp. 1–48, pl. 1.

YEN, T. C.
1950. A molluscan fauna from the type section of the Truckee Formation. American Journal of Science, vol. 248, no. 3, pp. 180–193, pl. 1.